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GENERAL STRIP CHART PLOTTING ROUTINE

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NOTICES

This final report was submitted by personnel of the Data Processing Branch, Biometrics Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 6319-03-22.

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This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Line plot	Log-log	Missing data
Histogram	Fortran IV	
Step function	CalComp	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a subroutine plotting package with its calling sequences and arguments providing the technical information needed to write graphic computer programs in Fortran IV programming language. It presents several examples showing different applications.

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GENERAL STRIP CHART PLOTTING ROUTINE

INTRODUCTION

A highly advanced general plotting subroutine package, BGNSTP, has been designed to meet the current needs of the USAF School of Aerospace Medicine and to allow easy expansion of these capabilities to meet future needs as they arise. The package is capable of plotting linear, semi-log, and log-log graphs, including the drawing of all scales with or without corresponding numeric values. It also provides complete titling functions for graph and curve identification.

BGNSTP is written in the Fortran IV programming language and uses the plotting commands of the CalComp Basic Software Package. It was originally written in Assembly Language for a Philco 2000 computer. With the updating of computer systems to an IBM 360, the subroutine package was converted to Fortran IV.

GENERAL DESCRIPTION

BGNSTP plots two paired arrays of single precision floating point numbers as points, connected points, or as a step function. Up to 10 such curves may be drawn with axes separate or common as desired. Additional segments of curves may be added. Provision is made for semi-log or log-log scales, for automatic incrementing of one coordinate, and for missing data. Thus this subroutine can be used to simulate, among others, a normal handplot of a function of an 8- x 10-inch page, a similar handplot of several curves on one page, or an analog strip chart of from 1 to 10 channels.

BGNSTP currently allows one axis and its scale to be extendable, either by calling a separate entry or automatically when the curve exceeds the maximum axis scale value. The subroutine provides the necessary interlinkage for plotting up to 10 segmented curves, where it is not desirable to retain all of the data for each complete curve in core at once. Each of these curves may have its own independent x- and y-axes and their associated scaling functions. The axis length and distance between numeric values are completely under programmer control. Axes may intersect in any manner desired or may not intersect at all. A single axis may be drawn, i.e., an x-axis may be drawn without a corresponding y-axis or vice versa.

Because BGNSTP currently uses CalComp drum plotters, the user operates under several hardware limitations. For example, the maximum width across the plotter roll is only 11 or 34 inches, depending on which size paper is being used, and at least 1/2-inch margin should be

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left at the sides of the plotter for the label and annotation, which further decreases the plotting area. However, the maximum length along the plotter roll (parallel to the sides) is limited only by the length of the paper, usually 120 feet.

CALLING SEQUENCE

The BGNSTP entry must be called first for each page of plotting to initialize the subroutine package. The scale factors for scaling a curve must be established before the curve may be plotted; i.e., BGNSCL must be called for each curve ID before the associated BPLOT entry is called. Also the user must terminate each page of plotting with the BNDPLT entry. The following sections explain the entries and their arguments.

CALL BGNSTP (NTYPE, ORIENT, TITLE, NWORDS, NPRINT)

The BGNSTP entry must be called once before each page of plotter output. It initializes the subroutine package and plots a page title.

NTYPE   A fixed point variable designating the type of plot scales and the number of log cycles desired across the plotter roll:

1) A positive integer (from 1 to 7) - A semi-log plot of 1 to 7 cycles.

2) Zero - A linear scale

3) A negative integer (from -1 to -7) - A log-log plot of 1 to 7 cycles.

ORIENT   A variable designating the paper orientation.

1) A positive variable - Orientation 1 is to be used.

2) A negative variable - Orientation 2 is to be used.

TITLE   The name of a single dimensioned array containing the page title.

NWORDS   A fixed point variable specifying the number of words in the page title. Note: The automatic title may be suppressed by specifying zero words for this argument.

NPRINT   A fixed point variable specifying whether error messages are to be printed. A value of zero (0) will inhibit the printing of error message.

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CALL BGNTTL (TITLE, NWORDS, SIZE, XCOOR, YCOOR, INFORM, ANGLE)

The BGNTTL entry provides for all titling needs after the page titling provided by BGNSTP. It allows a title to be lettered in either orientation (regardless of graph orientation) and at any angle.

TITLE The name of a single dimensioned array of 4-character words to be plotted.

NWORDS A fixed point variable specifying the number of words in TITLE.

SIZE A floating point variable specifying the height in inches of the symbols to be used in plotting TITLE.

XCOOR A floating point variable specifying the x-distance in inches from the grid origin to the TITLE beginning. See INFORM for details.

YCOOR A floating point variable specifying the y-distance in inches from the grid origin to the TITLE beginning. See INFORM for details.

INFORM A fixed point variable specifying the geometry in which the TITLE is to be plotted. Arguments XCOOR and YCOOR specify the position of the lower left corner of the first character of the TITLE.

 1) A positive integer (nonzero). TITLE is to be plotted according to the angle specified in argument ANGLE.

 2) Zero. TITLE is to be plotted across the page (parallel to the x-axis) with characters in the initialized graph orientation.

 3) A negative integer. TITLE to be plotted parallel to the y-axis.

ANGLE A floating point variable specifying the angle at which the TITLE is to be plotted if argument INFORM is a positive integer.

CALL BGNSCL (ID, FXMIN, FXMAX, FYMIN, FYMAX, KODEX, KODEY,
    XLNGTH, XBLPINT, YLNGTH, YBLPINT, XCOORDY,
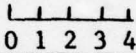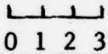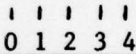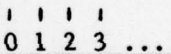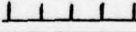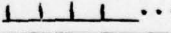   YCOORDY, XCOORDX, YCOORDX, SYMSZE)

The BGNSCL entry is used to establish the scale factors for any particular curve as well as to draw and label each axis for that curve.

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The scale factors for any curve must be established before BPLOT is
called to draw the curve.

ID   A fixed point variable, between 1 and 10 inclusive,
            identifying the curve.

FXMIN   A floating point variable specifying the minimum x-axis
            value.

FXMAX   A floating point variable specifying the maximum value
            of the x-axis or of its first extendable segment.

FYMIN   A floating point variable specifying the minimum y-axis
            value.

FYMAX   A floating point variable specifying the maximum value
            of the y-axis or of its first extendable segment.

KODEX   A fixed point variable specifying the x-axis format
            code. (Refer to Table 1.)

KODEY   A fixed point variable specifying the y-axis format
            code. (Refer to Table 1.)

XLNGTH   A floating point variable specifying the length in
            inches of the fixed length x-axis or extendable segment.

XBLPINT   A floating point variable specifying the distance in
            inches between the blips on the x-axis.

YLNGTH   A floating point variable specifying the length in inches
            of the fixed y-axis or extendable segment.

YBLPINT   A floating point variable specifying the distance in
            inches between blips on the y-axis.

XCOORDY   A floating point variable specifying the x-distance in
            inches from the grid origin to the y-axis.

YCOORDY   A floating point variable specifying the y-distance in
            inches from the grid origin to the bottom end of the
            y-axis, which ordinate corresponds to y = FYMIN.

XCOORDX   A floating point variable specifying the x-distance in
            inches from the grid origin to the left end of the x-
            axis, which abscissa corresponds to x = FXMIN.

YCOORDX   A floating point variable specifying the y-distance in
            inches from the grid origin to the x-axis.

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SYMSZE   A floating point variable specifying the height in inches of the characters in the numeric labels along the axes. Labels along an x-axis will be offset one-half of the height of the characters below the axis and centered beneath the blip. Labels along a y-axis will be offset one-half of the width of a character to the left of the axis and will be positioned immediately above the blip.

TABLE 1. FORMAT CODES FOR X- AND Y-AXES

Code	Axis Description	Example
0	A fixed length axis is to be drawn and labeled	└─┴─┴─┴─┘ 0 1 2 3 4
1[a]	An extendable axis is to be drawn and labeled	└─┴─┴─┘ 0 1 2 3
2	A fixed length axis with labels and blips only is to be drawn	ı ı ı ı ı 0 1 2 3 4
3[a]	An extendable axis with labels and blips only is to be drawn	ı ı ı ı 0 1 2 3 ...
4	A fixed length axis is to be drawn without labels	└─┴─┴─┴─┘
5[a]	An extendable axis is to be drawn without labels	└─┴─┴─┘ ...
6	Only the scale factors are to be established without drawing an axis	

[a]There can be only one extendable axis per page.

CALL BPLOT (ID, NOE, KTYPE, XARRY, YARRY, N,
FINC, INCSYM, SYMSIZE)

The BPLOT entry is used to draw a curve or curve segment. If the axis along the roll (previously specified in BGNSCL for this curve) is extendable and if the data to be plotted by this BPLOT call exceeds the previously drawn axis, then BPLOT will automatically extend that axis to a length equal to our greater than the maximum data point of that curve segment, using BEXTND.

ID   A fixed point variable, between 1 and 10 inclusive, identifying the curve.

NOE   A fixed point variable specifying the number of elements in each of the x- and y-coordinate arrays.

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KTYPE A fixed point variable specifying the type of curve:

1) +2 - A line plot with symbols at breaks in the curve indicated by missing data fixed point ones and at every Kth plotted point on the curve, where "K" is specified by INCSYM.

2) +1 - A line plot with symbols every Kth point on the curve, where "K" is specified by INCSYM.

3) Zero - A point plot

4) -1 - A histogram (step function) line plot with symbols at every Kth point on the curve, where "K" is specified by INCSYM.

Note: The step function will be drawn from the first point in XARRY, YARRY horizontally then vertically to the second point, horizontally then vertically to the third point, etc., to the last point.

5) -2 - A histogram (step function) line plot with symbols at breaks in the curve indicated by missing data fixed point ones and at every Kth point on the curve, where "K" is specified by INCSYM.

See preceding Note.

XARRY The name of a dimensioned array containing the floating point x-coordinates. Fixed point ones within this array will indicate missing data. This argument may be a fixed point two (2) to indicate that the x-coordinate will be automatically incremented. Under this condition, the initial x-coordinate for a curve will be the minimum x-value FXMIN specified in the BGNSCL entry. The x-coordinate is then incremented by the value specified in FINC for each coordinate in XARRY.

YARRY The name of a dimensioned array containing the floating point y-coordinates. Fixed point ones within this array will indicate missing data. This argument may be a fixed point two (2) to indicate that the y-coordinate will be automatically incremented. Under this condition, the initial y-coordinate for a curve will be the minimum y-value FYMIN specified in the BGNSCL entry. The y-coordinate is then incremented by the value specified in FINC for each coordinate in YARRY.

Note: Arguments XARRY and YARRY may not both be fixed point twos. This condition will result in an error message and a programmed stop.

N   A fixed point variable specifying that only every Nth element of XARRY and YARRY are to be plotted. For example, N = 1 will plot every point; N = 3 will plot every third point.

FINC   A floating point variable specifying the independent coordinate incrementing factor. This is used only in conjunction with the automatic incrementing option of arguments XARRY and YARRY.

INCSYM   A fixed point variable specifying the symbol density factor "K" for this curve when every Kth plotted point will be marked with the selected symbol, e.g., K = 0 for no symbols; K = 2 for symbols at every second plotted point.

SYMB   A hollerith constant whose leading character is to be used to label the points of this curve as often as specified by INCSYM.

SIZE   A floating point variable specifying the height in inches of the symbol specified in argument SYMB. Suggested normal range of heights would be 0.07 inch - 0.25 inch. A maximum of 0.3 inch is allowed.

CALL BEXTND (ID)

The BEXTND entry causes one extension to be drawn onto the specified extendable axis in the format originally specified in BGNSCL. (Refer to Table 1.)

ID   A fixed point variable, between 1 and 10 inclusive, identifying the axis to be extended.

CALL BOVPLT (ID)

The BOVPLT entry inhibits the connection of segmented curves between BPLOT calls when using the same ID.

ID   A fixed point variable, between 1 and 10 inclusive, identifying the curve which is not to be connected.

CALL BNDPLT (LAST)

The BNDPLT entry terminates each page of plotting.

LAST   A fixed point variable specifying:

1) Zero – The end of a page of plotting but not the end
   of the last page of plotting. This call is expected
   to be followed by either another BNDPLT call with a
   nonzero argument or by another BGNSTP call.

2) Nonzero – The end of the last page of plotting.

TECHNICAL DESCRIPTION

The subroutine scales all data before plotting to accommodate the
plotter page dimensions. The data to be plotted is scaled using the
arguments previously provided for the BGNSCL subroutine. Each coordi-
nate is scaled and stored in temporaries as necessary for plotting so
as not to destroy the data in the input arrays. All data values are
scaled by the following formulas:

Linear: $Y' = Ay + Y\ By$

$X' = Ax + X\ Bx$

Log: $Y' = Ay + (Log_{10}Y)\ By$

$X' = Ax + (Log_{10}X)\ Bx$

The A's (offsets) and B's (multipliers) are computed as follows (See
BGNSCL entry, p.3 , for explanation of the terms used):

Linear: $Bx = (XLNGTH)/(FXMAX-FXMIN)$

$By = (YLNGTH)/(FYMAX-FYMIN)$

$Ax = (XCOORDX + .5) - Bx\ (FXMIN)$

$Ay = (YCOORDY + .5) - By\ (FYMIN)$

Log: $Bx = (XBLPINT)$

$By = (YBLPINT)$

$Ax = (XCOORDX + 1.0) - Bx\ (Log_{10}FXMIN)$

$Ay = (YCOORDY + .5) - By\ (Log_{10}FYMIN)$

The CalComp software provides for only one axis orientation.
However, with BGNSTP two orientations are available for linear axis
pairs.

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Orientation 1 has x values measured across the roll from left to right and y values measured up the length of the paper roll. The range of x values is restricted to 10 or 33 inches depending on the size paper being used.
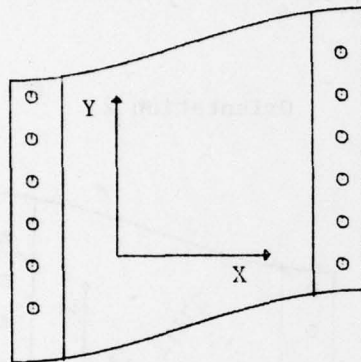
Orientation 1

Orientation 2 has x values measured along the length of the paper roll and the y values measured across the roll from right to left in such a way that the right margin at plotting time becomes the bottom of the plotted page. The range of y values is restricted to 10 or 33 inches depending on the size paper being used.
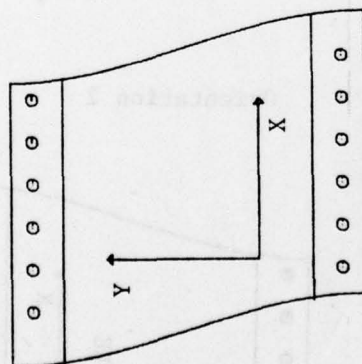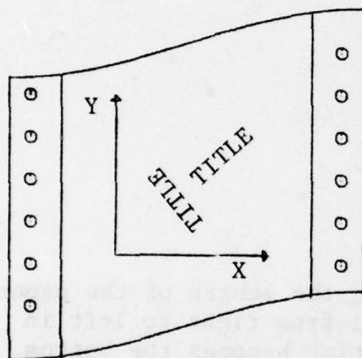
Orientation 2

Since all across-the-roll log scales are printed from right to left, only orientation 2 is available for log scales.

The titling function will allow as many titles to be drawn on a page as the user desires for graph and curve identification. The titles may be in any position on the page. Three forms of titles are available to the user. See argument INFORM in section "CALL BGNTTL." An angled title (refer to option 1 of argument INFORM) will be oriented as follows:

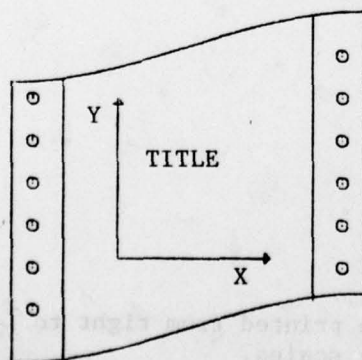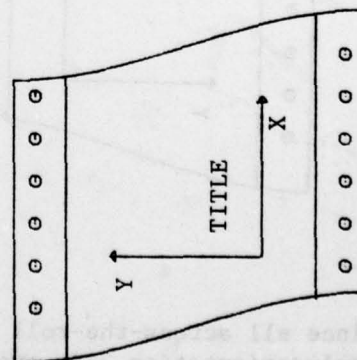Orientation 1   Orientation 2
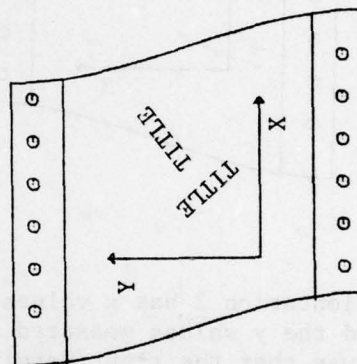
A normal title (refer to option 2 of argument INFORM) will be oriented as follows:
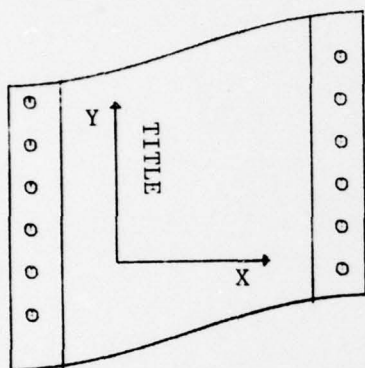
Orientation 1   Orientation 2
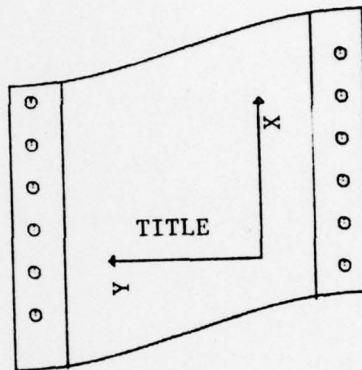

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A rotated title (refer to option 3 of argument INFORM) will be oriented as follows:

Orientation 1   Orientation 2

In summary, a plotting package with complete scaling and titling functions has been developed for drawing linear and logarithmic graphs. It provides for extendable axes, missing data points, two orientations, and step function plotting. An example using the plot package is shown in Appendix A.

APPENDIX A

PLOTTING EXAMPLES

```
      DIMENSION  FUNC1(100), FUNC2(100), FUNC3(100), FUNC4(100),
     1           FUNC5(100), FUNC6(100), TITLE1(3), TITLE2(4),
     2           TITLE3(4)
      DATA  TITLE1/'LINEAR PLOT'/, TITLE2/'LOG-LOG PLOT'/,
     1      TITLE3/'SEMI-LOG PLOT'/
      DO 40 I = 1,100
      FX = I
      FUNC1(I) = FX
      FUNC2(I) = FX + 100.
      FUNC3(I) = 100.0 * EXP(-0.02 * FX)
      FUNC4(I) = 100.0 * EXP(-0.02 * (FX + 100.0))
      FUNC5(I) = FUNC3(I) * 1.5 * SIN(0.125 * FX) + 100.0
   40 FUNC6(I) = FUNC4(I) * 1.5 * SIN(0.125 * (FX + 100.0)) + 100.0
C                                       GRAPH  1
      CALL BGNSTP (0, -1, TITLE1, 3, 0)
      CALL BGNSCL (1,0.,200.,80.,220.,2,0,10.,1.,7.,1.,.5,3.,1.5,3.,
     1          .14)
      CALL BGNSCL (2,0.,40.,0.,3.335,1,0,2.0,2.,6.67,2.,1.,0.,1.5,0.,
     1          .14)
      CALL BGNSCL (3,0.,200.,0.,100.,6,0,10.,2.,10.,2.,1.5,0.,1.5,0.,
     1          .07)
      CALL BPLOT (1,100,1,2,FUNC5,1,1.0,0,0,.07)
      CALL BPLOT (2,100,-1,FUNC1,2,1.,0167,10,1HA,.07)
      CALL BPLOT (3,100,0,FUNC1,FUNC3,1,0.,1,1H.,.21)
      CALL BPLOT (1,100,1,2,FUNC6,1,1.0,0,0,.07)
      CALL BPLOT (2,100,-1,FUNC2,2,1.,0167,10,1HA,.07)
      CALL BPLOT (3,100,0,FUNC2,FUNC4,1,0.,1,1H.,.21)
      CALL BNDPLT (0)
C                                       GRAPH  2
      CALL BGNSTP (-3, -1, TITLE2, 3, 0)
      CALL BGNSCL (1,1.,200.,1.,200.,1,0,10.,3.33,10.,3.333,0.,0.,0.,0.,
     1          .14)
      CALL BPLOT  (1,100,1,FUNC1,FUNC3,1,0.,20 ,1HB,.07)
      CALL BPLOT  (1,100,1,FUNC2,FUNC4,1,0.,20 ,1HB,.07)
      CALL BOVPLT (1)
      CALL BPLOT  (1,100,1,FUNC1,FUNC5,1,0.,20 ,1HC,.07)
      CALL BPLOT  (1,100,1,FUNC2,FUNC6,1,0.,20 ,1HC,.07)
      CALL BNDPLT (0)
C                                       GRAPH  3
      CALL BGNSTP (+2, -1, TITLE3, 4, 0)
      CALL BGNSCL (1,0.,240.,10.,1000.,1,0, 8.0,2.0,10.,5.,0.,0.,0.,0.,
     1          .14)
      CALL BPLOT  (1,100,1,FUNC1,FUNC5,1,0.,10,1HA,.07)
      CALL BPLOT  (1,100,1,FUNC2,FUNC6,1,0.,10,1HA,.07)
      CALL BNDPLT (1)
      STOP
      END
```
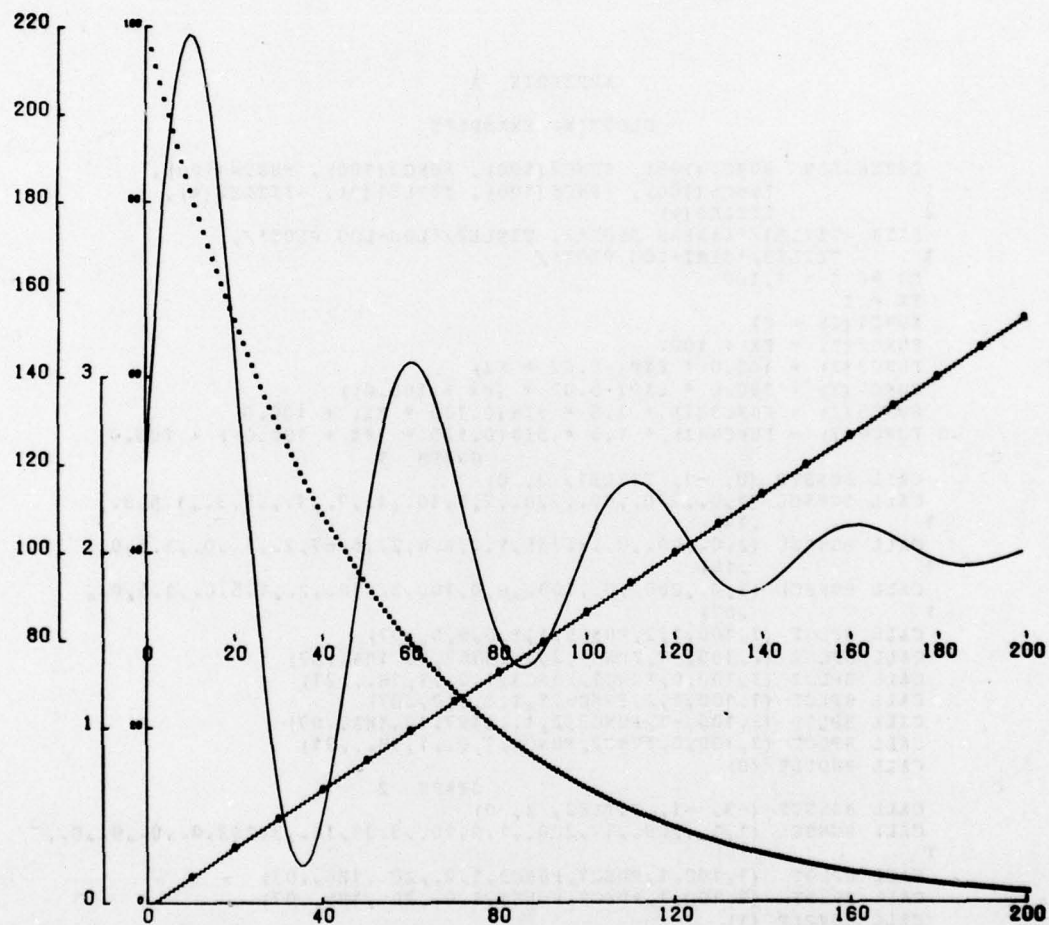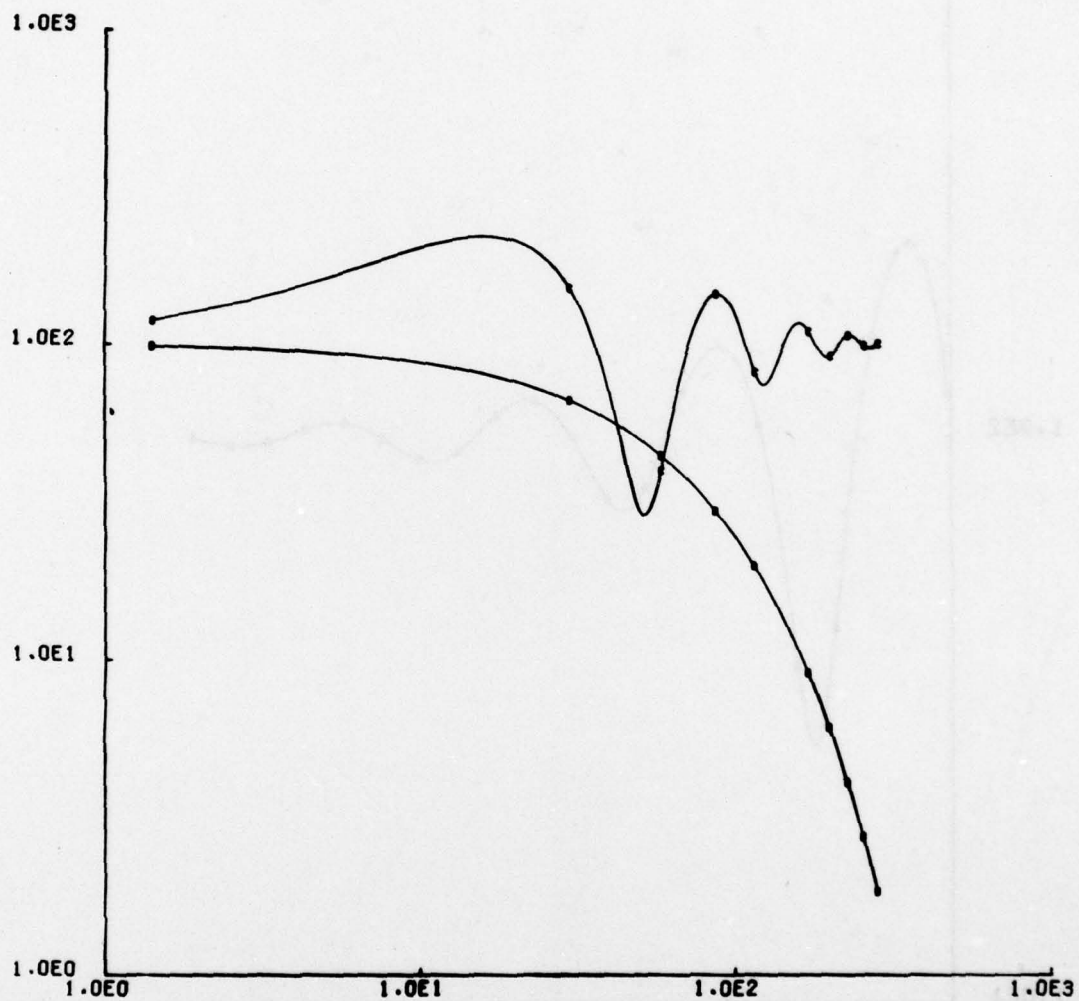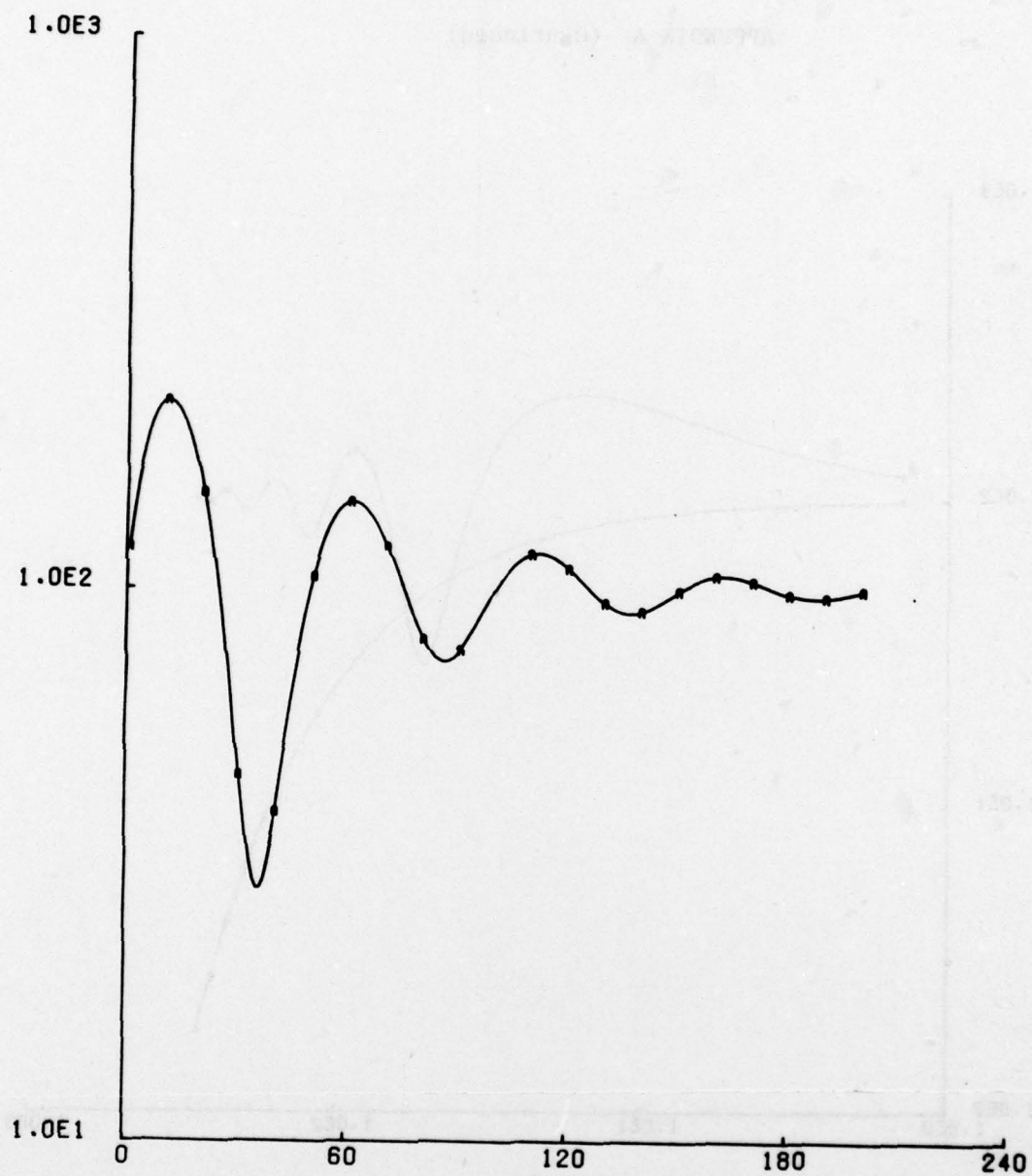
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Graph 1. Linear Plot

Graph 2. Log-Log Plot

Graph 3. Semi-Log Plot

GLOSSARY OF PLOTTER TERMINOLOGY

AXIS   - A line with or without blips and/or scale values pertaining to a particular curve. It may be plotted or merely used as a reference.

BLIP   - A perpendicular marker along an axis.

CURVE   - A complete set of plotted points, connected or not, corresponding to a functional relationship.

CURVE SEGMENT   - A section of a curve corresponding to an array of data completely contained in core storage.

GRID ORIGIN   - The grid line intersection to which the operator manually initializes the plotter.

HISTOGRAM   - A step function line plot whose line segments are all parallel to the axes. See BPLOT entry for details of plotting.

LINE PLOT   - A mode of plotting in which the pen remains down (in contact with the paper) as it moves from one point of an array to the next. Also the curve resulting from such a mode of operation.

LINEAR SCALE   - A scale such that one unit change in the values to be plotted always corresponds to the same number of inches on the plot.

LOG-LOG PLOT   - A curve whose axes both have a log scale.

LOG SCALE   - A scale such that the number of inches moved on the plot from one coordinate to the next is proportional to the difference of their logarithms.

MISSING DATA   - A data point in the X or Y array which is not to be plotted, indicated by a fixed point one (1). When this point is encountered, the pen is raised and moved to the next succeeding point.

PAGE OF PLOTTING- A set of curves all drawn with reference to a grid origin. They may have different axes however.

POINT PLOT   - A mode of plotting in which the pen remains up (not in contact with the paper) as it moves from one point of an array to the next. Also the curve resulting from such a mode of operation.

SCALE   - The relationship between an array and its corresponding plotted positions. See linear scale, log scale, and scale factors.

SCALE FACTORS   - Two constants specifying a scale.

SCALE VALUE   - The value associated with a particular point along an axis, in units of the original array.

SEMI-LOG PLOT   - A curve having a linear scale on the x-axis and log scale on the y-axis.

STRIP CHART   - A page of plotting, normally quite long in the direction of roll length, containing one or more curves having a common scale along the roll length. Normally the curves are nonoverlapping line plots, each running along a "strip" of the page.

SYMBOL   - A character drawn on a graph, to mark a coordinate point on a curve, or as an element of the title of a page or curve.

TITLE   - A series of symbols plotted to identify and/or to describe a curve or a page of plotting.

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